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AND ABSTRACT OF THE LITERATURE

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HONORARY CONSULTING EDITOR
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A. F. STANLEY KENT, A.M., D.Sc.

Dust in Printers' Workrooms

Influence of Industrial Noises

The Rehabilitation of Employees: An Experience with 1,210 Cases

Trinitrotoluene Poisoning
Its Nature, Diagnosis, and Prevention
(Continued)

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THE JOURNAL OF INDUSTRIAL HYGIENE

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DUST IN PRINTERS' WORKROOMS*

C. B. ROOS, B.Sc., F.I.C.

H. M. Inspector of Factories

DISCUSSION having arisen in the press as to the possible relationship between tuberculosis in printers and inhalation of silica dust, I was instructed to investigate the quantity and nature of the dust in the air of workrooms in which printing processes are carried on. Some silica is found in "printer's list," a black fluffy substance which collects in compositors' cases, and its existence there has been attributed to:

1. Sand used in casting and moulding iron "chases" (the metal frames into which the type is locked). When these rust, the sand is loosened and on releasing the type, silica and oxide of iron are shaken out.

2. Silica shaken off the chases by vibration in machines.

3. The "dross" which arises from the "list" when used type is melted down. This dross is skimmed off and often stored in open chests in workrooms for months until sold.

It was suggested that the silica was carried from the compositors' cases into the air by floating vegetable fibres produced by the paper. The paper fibre was clogged into the type in the machines; when the type was released, the fibre was distributed with the silica into the cases, then thrown out into the air, and inhaled while the compositor was picking out the type he wanted.

It appeared therefore that to test these theories information on the following points would be useful: (1) *quantity of dust* in the air of printers' composing and machine rooms, and particularly as to whether the amount was in excess of that found in the air of ordinary rooms; and (2) *nature and size of dust particles.*

Determinations of the dust were made both in old-fashioned works, where conditions of air space and ventilation were usually indifferent, and in up-to-date works, under the best conditions obtainable. Altogether eight works were visited, four "good," and four "indifferent." In every case the air was drawn in at the breathing level of the workers, either in the centre of the room, or in the most crowded part.

These determinations were made by a special apparatus designed by Mr. G. E. Duckering (1). Briefly, the method consists in drawing a measured volume of the air of the workroom through a weighed filter-paper and weighing the dust col-

* Reprinted from the Annual Report of the Chief Inspector of Factories for 1920 by permission of the Controller of His Majesty's Stationery Office.

lected on the paper. From these results a figure representing the dust content of the air, known as the "dust figure," is calculated, and can be used for purposes of comparison. The dust figure is the number of milligrams of dust in 10 cubic metres of air, this being a convenient standard to adopt.

The dust collected on the filter was submitted to microscopical examination (with polarised light) with a view to determining the size and character of the constituent particles. The results of these determinations are given in Table 1. The dust figures may be compared with those in Table 2, which were obtained (1) in the open air; (2) in a laboratory.

In view of the different suggestions as to the sources of the silica, samples of dust were collected from (*a*) fluff and dust from compositors' trays and cases; (*b*) dross from melting pots in casting rooms; and (*c*) paper fibre from machine rooms. During the investigation another possible source of dust was evident, namely, the French chalk used in the moulding process; a sample of this was also taken. These samples were analysed at the government laboratory, and the results of the analysis appear in Table 3. They can be compared with an analysis of a "domestic" dust.

Conditions in Printing Works

Composing Rooms. — In general, these rooms are not particularly well ventilated. Although in most cases plenty of windows (to open) are provided, they are usually found to be closed. The workers seem to prefer a warm atmosphere and object to windows being open. In some rooms, especially those used for newspaper work, there is much traffic, and in such cases the dust figure is higher than in rooms where traffic is restricted.

The dust in the trays is a woolly, felted, fluffy substance; but if the type is removed there is also found a fair quantity of fine black dust underneath the fluff. It is only to be expected that the trays, which are divided into small compartments, and only occasionally cleaned, will accumulate dust. When not in use the trays are stored away in a sort of cabinet, into which they fit like drawers. When an old case is taken into use after being disused for some length of time, an attempt is usually made to clear the dust from the small compartments. The old method of doing this, still used in many works, is to take the tray into the open air and blow the dust away with hand bellows. The more modern firms have installed dust extractors for this purpose. These are of two kinds:

1. A closed box with a fan and duct, known as the "Clements' Case Dust Extractor." The tray is placed inside the box, and the motor started. The action is threefold; the tray is agitated so as to stir up the type, the dust is blown up into the air inside the box, and drawn away by the fan through the duct into a special compartment, from which it can be cleared. The time taken to clear a tray by this method is about thirty seconds, as against fifteen to twenty minutes by the hand bellows, besides which there is no chance of the worker breathing the dust. Each compositor usually clears his own trays, as he requires them.

2. A vacuum cleaner, similar to those used for domestic purposes. A special worker is employed to go round the composing room, and keep all trays clean. Its disadvantages, as compared with the Clements' Extractor, are that there is no device for shaking up the type and so removing the dust underneath, and that light, thin pieces of type are liable to be lifted up with the dust by the suction, and carried inside the cleaner.

Machine Rooms. — Conditions in these rooms vary within very wide limits. Some are large and well ventilated, on the ground

floor, with good natural or mechanical ventilation. In many cases, however, the machine rooms are in the basement with artificial light constantly in use. They often appear to be overcrowded with machinery, their free ventilation being thereby restricted.

A certain amount of paper dust is usually found on the machines, the quantity varying with the kind of paper used. The principal varieties of paper met with are as follows, in the order of their dustiness:

1. *Antique wove.* — This is the dustiest paper on the market. It is used almost entirely for printing high-class novels.

2. *Antique.* — Used for cheap magazine work.

3. *News.* — Used for cheap newspapers, weekly periodicals, etc.

4. *Thin antique.* — Used for books.

5. *Smooth or calendered antique.* — Used for high-class newspapers, books, etc., and for the *outside* of weeklies and cheap magazines. A fairly smooth paper giving only a little dust.

6. *Calendered.* — Good smooth surface, giving very little dust.

7. *Super-calendered.* — Gives practically no dust.

In machine work where a dusty paper is used, the type has to be wiped frequently, as a bad impression is made in printing if the dust collects. The "clogging" of the type by dust and ink is therefore kept down to very small limits, to avoid spoiling the work. Moreover, after type is finished with and while it is still in the frame, or chase, it is usually washed with strong caustic potash solution, to remove the ink and paper fibre, before being broken up.

Moulding Rooms. — The chief characteristic of these rooms is the high temperature from the steam presses in use. The only possible source of dust is the French chalk used for dusting forms before and after moulding. Most firms use very little French chalk; in one case where a fair amount was used a suction fan was provided to assist in keeping the room clear of dust.

Casting Shops. — The processes carried on in these shops are:

1. Melting down of type (old and new). This is done in large pots, provided with hoods and ducts to carry off the fumes. The dross rises to the surface and is skimmed off. It is generally left until the next day to cool, when it is either placed in sacks or in a special closed metal bin, kept outside the workroom. It is disposed of to lead smelters (for recovery of the metal) and carted away weekly. Table 3 shows that dross contains no silica.

2. Pouring of molten type into moulds. This process gives rise to no dust.

3. Various trimming processes, *e. g.*, "routing," "shaving," etc. None of these is a dusty operation.

Linotype and Monotype Machine Rooms. — The machines give rise to little dust; the fumes given off by the melting pots are in most cases efficiently removed by exhaust ventilation.

Consideration of Results

In Table 1 the results have been arranged so that the amounts of dust in the air for the various processes are grouped together.

Composing. — Table 1 seems to show that the following factors have a determining influence on the size of the dust figure:

1. Size of room, in relation to the number of workers, *i. e.*, amount of cubic space for each worker.

2. Amount of traffic in room.

3. Amount of ventilation, *i. e.*, rate of change of air in the room.

Number 100 has the highest figure (24.4) for all composing rooms, the room being rather crowded, with much traffic. Number 107 is next, with a figure of 19.5;

TABLE 1. — RESULTS OF DETERMINATIONS OF DUST IN THE AIR OF PRINTERS' WORKROOMS

Lab. No.	Firm No.	Process	Where Taken at Breathing Level	Approximate No. of Cu. Ft. per Person	Dust Figure (Mg. Dust per 10 Cu. M. of Air)	Results of Microscopical Examination					Remarks
						Silica		Nature	Remainder		
						Size of Particles	Proportion of Total Dust		Size of Particles	Proportion of Total Dust	
						mm.			*mm.*		
99	1	composing.....	centre of room	1,600	14.6	0.004–0.04	small	Vegetable fibre and carbonaceous matter	....	small	Large room, few workers. Air very still, no traffic. All windows closed.
100	2	"	" " "	1,000	24.4	0.004–0.04	"	Same as No. 99; also a little flaky mineral substance	....	"	Rather crowded room, much traffic.
105	4	"	" " "	1,200	14.6	0.004–0.04	very little	Same as No. 99	....	nearly all	Large room, well ventilated. Fair amount of traffic.
107	5	"	" " "	800	19.5	0.004–0.04	" "	" " " "	....	" "	Windows all closed. Air oppressive. Several platen machines in room.
110	6	"	" " "	800	7.4	....	....	" " " "	0.004	all	Well-ventilated room, all windows open. Little traffic.
111	7	"	" " "	1,200	7.3	....	....	" " " "	0.004	"	Large room, few workers. No traffic.
113	8	"	" " "	5,500	7.3	....	....	Same as No. 100	up to 0.07	"	Large lofty room; a model composing room. Good ventilation. Fair amount of traffic.
115	9	"	" " "	800	18.2	....	....	Same as No. 99	....	"	Large room, well ventilated, but rather crowded, and much traffic.
103	2	machine work (rotary machines)	" " "	1,000	11.6	....	very little	Same as No. 100	0.04	nearly all	Large room, but many machines. Air oppressive. "News" paper being used.
106	4	machine work (flat bed machines)	" " "	4,400	14.5	....	....	" " " "	....	" "	Good large room, well ventilated. Very dusty "antique" paper being used.
108	5	machine work (rotary machines)	cutter end of machine	1,500	31.7	....	trace only	Same as No. 100; vegetable tissue with cell structure	up to 0.01	" "	Low ceilinged room, much machinery. Rough "news" paper.
109	6	machine work (flat bed machines)	between two machines	3,000	4.9	....	" "	Same as No. 99	under 0.004	" "	Well-ventilated room, with permanent ventilators in roof. Smooth calendered paper.
112	7	machine work (platens)	centre of room	450	18.3	....	" "	" " " "	" "	" "	Small crowded room in basement. Ventilation poor. Calendered paper.
114	8	machine work (flat bed machines)	" " "	3,000	1.0	....	" "	" " " "	" "	" "	Large, lofty, well-ventilated room. Calendered paper.
106	9	machine work (rotary machines)	" " "	4,200	9.8	....	" "	" " " "	" "	" "	Well-ventilated room. Calendered paper.
101	2	Moulding.....	centre of room (near press)	1,800	24.4	....	very little	Same as No. 100	0.01–0.04	" "	Much French chalk used. Mechanical ventilation by fan.
102	2	Casting.....	centre of room (near press)	2,200	24.4	....	" "	" " " "	0.01–0.04	" "	Low, dark room, much machinery. Ventilation fair.

the ventilation was poor, and the presence of platen machines raised the dust content of the air. Number 115 (18.2) was a well-ventilated room, but was somewhat crowded, and much traffic was going on. Numbers 99 and 105 have the same figure (14.6); in one case all windows were closed and there was no traffic, and in the other case there was good ventilation and much traffic. The lowest figure of all is 7.3, obtained in two cases in which all the factors contributed to a low dust content. The average figure for the eight samples is 14.1.

Machine Work. — Here, besides the air space and ventilation, the kind of paper in use is seen to influence the figure. Number 108 is highest (31.7), the ventilation being indifferent and the paper dusty. Number 112 was taken in the least satisfactory room encountered, but the paper used was of a smooth, calendered type, so that the dust figure (18.3) is moderate. Number 114 was taken under what might be termed ideal conditions — a large, lofty, well-ventilated machine room, and a smooth calendered paper. The dust figure (1.0) is practically negligible. The average figure for the seven samples is 13.1

Moulding and Casting. — The dust figure in these rooms (24.4) is somewhat in excess of the average figure for machine and composing rooms. This is explained, in the case of the moulding room, by the quantity of French chalk in use, and, in the case of the casting room, by the relatively large amount of traffic at the time of sampling.

Results of Microscopical Examination (Table 1). — This examination was carried out by Dr. H. H. C. Thomas, D.Sc., at the Geological Survey and Museum, Jermyn Street. The results show that, in all printing processes, the quantity of silica in the dust of the air is extremely small — in some cases so small as to escape detection. It appears, therefore, that the workers breathe very little, if any, silica. The dust consists for the most part of vegetable fibre and carbonaceous matter. In one case (No. 108), in which a rough "news" paper was being used, the vegetable fibre is described as having "good vegetable tissue with cell structure. The tissue and structure indicate straw or grass particles." Possibly some variety of straw or grass had been used in the manufacturing of the paper. In all cases the vegetable fibre is described as being "not such as would be yielded by filter paper," *i. e.*, by the material on which the samples were collected.

TABLE 2. — RESULTS OF DETERMINATIONS OF DUST IN AIR AND IN ROOMS WHERE ATMOSPHERE WAS NOT DUSTY

Point at Which Determinations Were Made	Milligrams of Dust in 10 Cubic Metres of Air
Centre of garden, Edgbaston, after three fine days	2.1
Same point after four days of fine weather	2.8
Same point after thirty-six hours of heavy rain	0.7
Centre of study, Edgbaston	7.7
Open air outside laboratory, Stoke, centre of a manufacturing district	9.4
Centre of laboratory, Stoke	18.5
Side of laboratory, Stoke	10.8
Side of laboratory, Oxford	12.6

Table 2 shows the results of determinations of dust in the open air and in rooms where the atmosphere was not dusty.

The dust figure of the atmosphere appears from these determinations to vary from 0.7, under ideal conditions (open air after heavy rain), to 18.5, this being the figure in a laboratory in a manufacturing town. Out of eight samples taken in composing rooms, in only two cases is this latter figure exceeded, and out of seven samples taken in machine rooms, in only one case, while the average figure for both these classes of work (14.1 and 13.1 respectively) is well below. Moreover, the figure 18.5 represents the dust in the air of an empty room with no traffic of any sort. A com-

parison of Tables 1 and 2, therefore, shows that printers' workrooms are by no means dusty.

Table 3 shows the results of analyses made at the government laboratory of nine samples of dust taken from printing works. This table gives the analysis of the sources from which it has been alleged that silica may get into the dust of the air. The highest percentage of "free" silica found is 6.31, the average being 3.35. Silica dust is comparatively heavy, so that the percentage of silica actually breathed by the worker is probably much lower than this. The remainder of the silica in the samples, included from the heading of "total silica," is present in the combined form, as silicates, in which form it is considered to be innocuous (2).

The following is an analysis of a sample of "dross": antimony, 16.49; lead, 68.23; tin, 12.50; copper, 0.12; iron, 0.09; zinc, 0.26; arsenic, 0.09; oxygen, 2.22; total, 100.00. It shows that dross, which is one of the alleged sources of silica, is entirely of metallic constitution. When type is melted down, the oil and other organic matter rise to the surface and are vaporised, the vapours passing into the hood above the casting pot. A certain amount of the metal separates from the alloy in a granular condition and is skimmed off. These skimmings are the dross and consist entirely of metal and occasionally a little metallic oxide.

"Total silica" in dust from printing works, when compared with that of London "domestic" dust taken from the top of a wardrobe,* comes out much the lower of the two.

TABLE 3. — RESULTS OF ANALYSES OF DUST SAMPLES FROM PRINTING WORKS

Sample No.	Firm No.	Where Taken	Organic Matter and Moisture	Lead	Other Heavy Metals	Total Silica	Other Inorganic Substances	Total	"Free" Silica (Included in Total Silica)
1	1	Type cases, composing room.....	66.00	2.80	3.20	8.95	19.05	100.0	4.33
2	1	Inside Clements' dust extractor..	59.00	8.92	4.08	9.96	18.04	100.0	6.31
3	2	Inside Clements' dust extractor..	40.00	23.75	6.25	8.63	21.37	100.0	1.32
4	2	Machine room.....	71.00	....	traces	11.45	17.55	100.0	2.50
5	2	Inside fan in moulding room.....	47.00	0.51	0.49	13.23	38.77	100.0	3.16
6	5	Type cases, composing room.....	68.00	4.68	1.32	8.48	17.52	100.0	3.21
7	9	Inside dust extractor.....	56.00	4.39	1.61	13.72	24.28	100.0	4.24
8	4	Machine room.....	74.00	traces	traces	12.00	14.00	100.0	1.78

Conclusions

1. Printing cannot be described as a "dusty" trade. The average quantity of dust in the air is no higher, and in some cases considerably less, than that in the air of many occupied rooms.

2. The dust in the air contains very little silica — in some cases a negligible quantity.

3. The dust in compositors' cases, in machine rooms, and in other dust-producing sources contains less silica than dust collected from a living room.

4. On the grounds of the presence of lead alone in the dust of the type cases, it is desirable that some apparatus, such as the Clements' Case Dust Extractor, should be used, particularly in large works, for removing the dust from the trays and cases. Such apparatus should be so constructed

* The analysis of this is given by Sir J. Crichton-Browne in the *Times* of Nov. 3, 1920, as follows: moisture, 4.4; organic matter, 52.6; silica and insoluble silicates, 21.0; iron oxide and alumina, 9.7; lime (CaO), 6.2; carbonic acid, with traces of sulphuric and phosphoric acids, 6.1; total, 100.0.

that the dust does not escape into the air during the process of removal.

The laboratory work in connection with the dust determinations was carried out by me at the South Western Polytechnic Institute, Chelsea, and the thanks of the Department are due to the authorities for the facilities given.

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INFLUENCE OF INDUSTRIAL NOISES*

D. J. GLIBERT, M.D.

Chief Medical Inspector of Factories, Brussels

THIS memoir — a résumé of all that was known in 1914 in regard to the influence of industrial noises — was originally written at the request of the Third International Congress on Occupational Diseases due to be held at Vienna in the later half of August, 1914, and was intended to open the debate on the subject. As the author lived in the occupied part of Belgium during the war, he had no access to new work, but nothing new appears to have been discovered, except that we have since learned of the idea that deafness following an explosion is usually temporary except when the auditory nerve is affected. It seems wise, however, to re-introduce so important a subject in order to stimulate research on the part of ear specialists. The influence of noise, which is at times deafening, has been little studied in spite of the fact that it is present in nearly all industries. The author, although not an ear specialist, feels justified in writing this résumé because it states the present position; because there is confusion among ear specialists; and because of his twenty years' experience in factory work which has enabled him to bring out the etiological factor in questions on which industrial doctors require a solution from ear specialists.

Deafness as an Occupational Disease or Accident

Deafness as an occupational disease should be studied separately from deafness caused by traumatic lesions due to explosions, gun fire, blasting, etc., which cause immediate lesions, although the difference is perhaps somewhat subtle. Save in special cases where initial lesions are clearly recognized as immediate, it is only after repeated injuries that ear affections become obvious, and therefore it is nearly always convenient to classify the deafness of gunners and firers of mines among occupational diseases rather than among accidents. Consequently, for practical purposes we may include the affections caused by injurious action of the air during firing among ear injuries caused by noise proper.

Outline of Previous Investigations

Classic writers on occupational diseases are generally reticent on the subject of disorders caused by noise in industry. Layet (1) points out that the deafness of coppersmiths was known of old and that sheet iron workers, coppersmiths, blacksmiths, and coopers are nearly always hard of hearing and become more so the longer they remain at their trade — a perversion of hearing shown by increased perception of high notes or loss of perception of low notes. Layet observed an old foreman who appeared to hear only in the midst of the greatest noise, while at other times he complained of continual buzzing in his ears, so that he was an example not only of the phenomenon of Willis but of other ear trouble. This phenomenon of Willis (hearing better when a certain sound is present than under ordinary conditions) is frequent in noisy industries, where another phenomenon is also observed which must not be confounded with that of Willis — namely, the power of certain workers to converse together in a nearly normal voice when a

* Translated from *Bulletin du Service Médical du Travail*, Jan., 1920, No. 1, by Dr. S. A. Henry, H. M. Medical Inspector of Factories, Manchester, England. Received for publication May 2, 1921.

stranger is at the time deafened and incapable of making himself heard without raising his voice. In factories for removal of coarse hair from furs by machinery or in works where hatters furriers' processes are carried on amid intense noise, I have often observed the workers laughing and talking together when I could not hear the sound of their voices. Is there a special adaptation of the worker's voice or a particular accommodation of the organism of the ear, or both? Be it as it may, this phenomenon is not necessarily accompanied by a diminution of hearing in a quiet atmosphere.

According to Roosa, workers in a noisy atmosphere get a true nerve lesion; they hear less well and do not recover their acuity of hearing except by staying off work for some time, and eventually the auditory trouble becomes permanent. According to Dr. Moure of Bordeaux, the more the noise produced in a small, closed and resounding space, the more rapid is the damage to the auditory nerve; that is why he considers as the most exposed young persons who are employed in coppersmiths' workshops to assist riveters in the interior of boilers in holding rivets in place during hammering. It is necessary to class with this group young persons who enter the boilers for the purpose of removing the deposit (boiler cleaners). My personal experience confirms the fact that these workers at times leave this noisy atmosphere absolutely dazed, deaf, and in a state of vertigo which lasts for several minutes. These facts may be compared with those observed in ironclads after a sea battle and in this connection De Merrys reports that on the Cesarewitsch, twenty-four hours after the engagement, many men complained of headache, loss of memory, and deafness.

Other influences, however, than that of a resounding medium can be cited to explain auditory lesions of workers in an enclosed space. Della Vedova of Milan, at the Seventh Italian Congress of Laryngology and Rhinology, insisted on good ventilation in enclosed spaces and pointed out among the causes harmful to hearing, dust, irritating gases, high temperature, dampness, and variations of atmospheric pressure, and cited as a proof of the injurious influence of a confined space the fact that among soldiers inflammatory conditions of the ear are less frequent during manoeuvres than during life in barracks.

As far back as 1877, the replacement on railways of shrill toned whistles by those of a deeper note or by other signals, such as bells, was suggested. Hedinger, in 1882, tested the hearing of 1,100 railway employees and found only 48 per cent. of hardness of hearing among engine drivers and stokers as against 95 per cent. among the other employees. He concludes that intemperate habits are much more the cause of catarrhal affections of the ear than is the engine whistle. Guterbock states that hardness of hearing among engine drivers increases in proportion to the length of service, as the following table shows:

Years of Service	*Percentage of Defective Hearers*
Less than 5	5.8
From 5 to 9	7.3
From 10 to 14	8.0
From 15 to 19	31.8
More than 20	52.1

Dr. G. Boval likewise states that the deafness of engine drivers and stokers increases with age and years of service from 11.7 to 62 per cent. according to age, and from 18 to 75 per cent. according to years of service. Barr makes similar observations on 100 persons; after seventeen and one-half years' service none heard a watch normally, fifty could not hear the low voice, thirty-three perceived it with both ears, and eight with only one ear.

It is surprising that observations in textile industries are rare. Röpke (2) refers to the examination of twenty spinstresses,

fourteen of whom were hard of hearing, and of fourteen weavers, none of whom heard normally. Dr. E. Coosemans, at the Sixth International Congress of Otology held in London in 1899, read a paper on hearing among "beetlers," who, after ten or twelve hours of daily labor, exhibit more or less marked deafness, which diminishes after a few hours, and which becomes normal after a Sunday's rest.

Another injurious occupation is that of telephone workers. Capart (3), reporting upon the telephone industry, stated that: (1) Occupational use of the telephone is a cause of fatigue to the ear, which may be aggravated too far by certain circumstances, such as production of induction currents, sudden opening and shutting of the circuit, etc.; and (2) fatigue and overwork of telephonists are at times the cause of various neuroses, neurasthenia, hysteria, etc. However, others, as Dr. N. R. Blegvad (4) are less pessimistic and do not think that telephone work hastens, or makes active, pre-existing ear affections. Generally the power of perception of high sounds is little altered. Of 354 telephone employees examined with regard to the lowest sound perceptible to the normal ear (sixteen vibrations), seventy-five could not perceive it on one or both sides. Blegvad admits that among certain individuals employment can cause earache, buzzing, vertigo, or Ménière's syndrome. Recently Dr. Trétrôp of Antwerp (5) reported two ear accidents, one to a telephone girl, and the other to a merchant speaking on the telephone, which he attributed to the too sudden breaking of a current of which the voltage had lately been increased to 20 volts.

Attention was first drawn to the action of reports and explosions on the ear when the use of gunpowder was introduced. Ambroise Paré taught us that heavy artillery could cause ear lesions and cerebral concussion. Layet (6) mentions the investigations of Percy who pointed out hemorrhages following a ruptured tympanum, with persistent severe headache, more or less pronounced disturbances of hearing, and refractory otitis following on the non-cicatrization of the rupture. He also recalls Barthelemy's remarks on a momentary hardness of hearing with hissings, buzzings, and "still noises," (proof of nerve trouble) met with among gunners after firing. These observations, however, were made before war was brought to a fine art, and require re-investigation to prove whether or not they are true.

Delsaux has analyzed all the work on the noise of explosions and firing, and recalls the work of R. Müller who examined fifty-one gunners, noting the extent of their hearing before firing and three days after. Six were excluded because their ears were plugged with wax; of the remainder examined before firing, thirty-four were normal and all the others had symptoms of actual disease or signs of old cicatrices. After firing, fifty-two ears remained *in statu quo* and all the others showed tympanic congestion. There were seven cases of hemorrhage of the tympanum but none of rupture of the membrane. The duration of perception of the tuning fork by bone conduction was shortened. On the subject of air conduction, the author is reticent and calls for further investigation. It is the experience of Cheatle, in England, that naval officers are more affected than their men and that the very high tone of guns of small calibre and of machine guns is more injurious than that of big guns. In addition, autopsies as well as experiments on animals corroborate the fact that occupational noises are capable of seriously injuring the organs of hearing.

Elementary Knowledge

In reading works on the subject of the influence of industrial noises, one is constantly meeting vague expressions, such as

"muffled sounds," "light sound," "great noise," etc., which it is necessary to define uniformly.

It is generally admitted that all sounds and noises which the ear receives can be referred to musical sounds. Noise proper is composed of a rapid and irregular succession of different auditory sensations. Sound, on the contrary, is uniform, calm, and without variations in its component parts. It possesses three principal qualities which are peculiar to it: intensity, resulting from amplitude of vibration and diminishing by distance in proportion to the square of the distance, from the fact of the diminution of the amplitude of vibrations transmitted; height, which increases with the number of vibrations; and tone, which depends on the harmonics, "superior or inferior," of the fundamental sound. Certain authorities add to intensity, height, and tone the idea of duration. To these intrinsic qualities of sound must be added an extrinsic quality described thus by Helmholtz: "In the main, in sounds of equal strength the sensibility of the ear changes with the height of the sound." Zwaardemaker (7) formulates the following conclusions as to this variable sensibility of the ear for different sounds:

1. The maximum sensibility of the human ear responds to 3,072 double vibrations (g4 of the German notation, sol 6 of the French notation).

2. The zone of very distinct sensibility extends from 256 double vibrations to 6,144 double vibrations.

3. Outside this zone to the limits of the scale, sensibility diminishes considerably.

There are three principal theories of the way in which sound is perceived:

1. *Helmholtz's Theory.* — The organ of Corti vibrates in concert. The elements of the internal ear are attuned to different heights of sound; low sounds are perceived by the part furthest from the base of the cochlea, while sharp sounds are perceived nearest this base.

2. *Hydrodynamic Theory of Bonnier* (8). — The liquid of the cochlea moves in bulk and rubs the sensory epithelium. Bonnier compares the organs of the ear not to resonators, but to registers.

3. *Pressure Theory of Marage.* — The perception of sounds is due to differences in the pressure of the endolymph, with no definite auditory localization.

Musical sounds proper are met at times in industry, as in hammering deep-toned metals, but these more or less pure sounds are rarely isolated. More usually noise proper is heard, but that also has its intensity, height, and tone. It is comparatively easy to determine experimentally the relative intensity of an industrial noise when it is regular and more or less continuous and can be compared to another noise, a short distance away, of constant intensity and sufficient to rise above it. The measure of the displacement required would give the relative intensity. Exact estimation of the height of noises is much more difficult, and we must, for the most part, rely on a few observers for this information. Although a well-trained ear learns by practice to grade the tone of noises by comparison with a known height of tone, it would be more satisfactory if the ear specialist would furnish a precise method of determining as nearly as possible the notation of different noises. Tone, on the other hand, can be described with sufficient precision for practical purposes. It characterizes the source of noise; it enables one to distinguish various machines in action, without seeing them; and, in combination with height, it gives to certain noises that disagreeable character which is peculiar to them — *e. g.*, the rasping noise in the finishing off of white stones, or the grating of saws or files. When it has this unpleasant character, tone is important in observations, as it inevitably has an ill effect on persons of nervous temperament. It is also necessary to pay attention to the

rhythm, and the continuity, regularity, or irregularity of a noise essentially uniform are also factors to be dealt with. The unexpectedness of certain short, loud noises bursting forth at rather long intervals has a disagreeable effect on the nervous system. Finally, it is necessary to have comparative information on the subject of intensity of vibration communicated to the ground and to the body of a worker by the vibrating of noisy machines. This information is not difficult to obtain.

Noisy Trades

It would be wrong to imagine that all the employees in a brass foundry, in large iron works, or in shipbuilding yards are equally exposed to noise in their work. We must have a reasonable classification which will serve to show that it is necessary in each group to take into account accessory circumstances. Take, as an example, flax spinning which must be carefully distinguished from weaving of linen, just as it must not be confounded with "steeping" and "stripping" or "scutching," — the operations which precede it.

In a linen factory one meets all the scale of noises: there are quiet processes, as winding, or reeling, and heckling; less quiet processes, as drying and packing; noisy ones, as combing by machinery, carding; and, finally, very noisy ones, as in the preparing rooms and spinning rooms where the noise is so great that orders have to be given by means of a shrill whistle. Hence, one sees the inaccuracy of medical observation which is limited to describing the examinees as workers in the linen industry. Carding, preparation, etc., irritate the nasopharynx by dust, and spinning gives rise to similar trouble because of the humidity and heat which may cause "chills." Combing by machinery exposes the young worker to dust and muscular strain.

In many factories the noise is great in certain places and not in others, as in metal stamping, especially in making metal boxes. Very often in these works there are quiet corners, also the noise of one stamping machine varies from another, and curiously enough it is not always the stamper who is most exposed to the noise of his own machine. Certain other occupations are quite unknown to aurists. How many of them suspect that in the preparation of little rubber objects such as nipples for feeding bottles and toy balloons, there exists at times noise comparable to that of the loudest hammering. These examples are sufficient to prove the necessity for medical inspectors of factories to draw up a list of noisy industries which would serve as far as possible as a basis of comparison, and to point out all the other peculiarities which may influence health. The ear specialist ought to be in possession of all the facts before he pronounces on the etiology of a lesion, and he should take into account all the causes other than noise which could explain in part or in whole the malady observed.

In addition to information in regard to noise, the aurist should know in detail the peculiar health conditions of certain trades. Lesions of the middle ear or nasopharynx are in themselves a menace to the integrity of hearing. Noise being equal, trades which specially expose a worker to these lesions are more harmful to hearing than others; hence, the necessity of paying attention to different accessory risks, such as mercury, carbon bisulphide, and especially lead, which is a poison to the internal ear. Irritant vapors, or acid fumes, and toxic gases, such as carbon monoxide, in the form of slow chronic poisoning attack hearing as well as memory. In the same way, it is necessary to note the influence of heat, humidity, and dusts. Moreover, the influence of fatigue, muscular and intellectual, must be remembered. Fatigue in

itself lessens auditory acuity even when not excessive. For example, examination of twenty-four bicyclists who had ridden 50 kilometers showed that air perception was diminished, especially for sharp sounds (9). After a few hours' rest hearing had already improved. Finally, it must be remembered that ear lesions are often accompanied by loss of sense of space (vertigo, Ménière's syndrome), and in this connection I wish to note the occupational risk on ladders, scaffolding, and work in particularly dangerous places.

Nature of Lesions

According to Layet, most authors think that noise is a determining factor in causing a true lesion of the auditory nerve. At the autopsy of an old coppersmith afflicted during life with occupational deafness, Habermann found degeneration of the organ of Corti and other nerve elements at the base of the cochlea. Similar lesions were found by the same author at the autopsies of several other subjects afflicted with deafness which was considered to be due to occupation. Moure, of Bordeaux, is of the opinion that, when the occupational disease is established and, in spite of rest, hearing does not return, it is a question of deep-seated trouble — a labyrinthine affection, of which the diagnosis is certain and proved by acoustic tests, before the absence of lesions of other parts, such as tympanum, tubes, and ossicles, is objectively proved.

Wittmaack has made considerable progress in the question of lesions caused by noise. He has demonstrated that animals, subjected under certain conditions to the action of a noise of varied duration, with or without rest, show profound lesions. On microscopic examination the middle ear appeared intact, as did also the vestibule, while obvious changes were seen in the internal ear in the region of the cochlea. Wittmaack's work has been controlled by Professor Siebenmann and his pupil, Dr. Yoshii, with varied intensities of sound. These authors constantly found visible and characteristic anatomic lesions of the organ of hearing. These lesions, varying with the sound used, took effect on the organ of Corti, and the nerve fibers and cell ganglia. It is useful also to recall that, with a pure sound, always the same, Wittmaack found a lesion of the cochlea peculiar to itself in each case.

H. Marx, of Heidelberg, experimenting on guinea-pigs under conditions similar to his predecessors, obtained similar results, at least in the main points. The degeneration of the organ of Corti, however, was found to be situated a little further from the base of the cochlea than that found by Wittmaack. Von Eicken, studying the action of deep sounds produced by organ pipes, states that, when the middle ear is normal, certain deep sounds cause alterations of the cochlea at the level of the second turn of the spiral. Other deep sounds, on the other hand, appear harmless. Delsaux summarizes the conclusions to be drawn from the patient, and extremely careful, researches of Haenli. Violent excitation of hearing, or reports, attack at first the terminal organ which they destroy in a certain way and it is only later that the neurones atrophy. Later still, there appear alterations in the membrane of Reissner.

A good synopsis of the results of Wittmaack's, Siebenmann's and Yoshii's experiments is found in the very instructive work of E. J. Moure and P. Cauzard on functional examination of the labyrinth (10). The authors of this work are inclined to consider the experimental results as proved definitely, and allow the following assertions of Wittmaack: (1) the integrity of the vestibule in lesions due to noise; (2) the destruction or alteration of the same section of the cochlea by sounds

of the same instrument (whistle). In a personal communication to these authors, Siebenmann expresses himself thus: "It follows (from the experiments of Wittmaack and his school) that a pure sound only affects a single point of the cochlea and that the lower the sound is, the higher the point is found in the cochlear region."

From the analysis of twenty principal clinical works on the results of reports and explosions, Delsaux concludes that the disorders of hearing or the lesions of the ear arising from these causes may be classified as: (1) lesions of the tympanum; (2) lesions of the drum; (3) disturbance of the labyrinth; (4) progressive deafness; and (5) diverse nervous disorders. He states that all experiments tend to show that, apart from ruptures of the tympanum and lesions of the drum, and, in rare cases, lesions of the ossicles, injury to the ear by detonations gives rise in the internal ear to temporary or progressive or definitive lesions, situated mostly in the tympanic slope of the cochlea and rarely and temporarily in the vestibular slope or in the static apparatus of the internal ear. Finally, it is well to keep in mind the views suggested to Layet by Dr. Moure, namely, that when the organs are intact the principal industrial noises act on the labyrinth, while reports and explosions may also act directly on the organs of the middle ear.

Transmission of Noise by Air and by Solid Substances

Must one blame noise transmitted at the same time by air and by solid bodies? Must one, on the other hand, consider air vibration alone as practically harmless and blame chiefly vibrations and tremors which are communicated to the bony skeleton? This is a necessary point in prophylaxis. It is a problem, the solution of which, if it can be obtained, will revolutionize the methods of protecting the worker and the legal measures formulated by different governments.

The accidental results of great explosions or a sudden change of pressure among workers in an atmosphere of compressed air must be excluded. These are cases of "superior force," the effects of which cannot be used as a proof for or against the theory as to the cause of it. Would it not be wise also to exclude the results of reports and explosions knowingly caused? Truly, the deafness of gunners is an occupational one, but the conditions producing it are not met with in industry, except quite exceptionally among those employed in shooting galleries or attached to depots for testing firearms. In firing a mine, it is obviously wise that workers who start the fuse should be as far away as possible, and consequently lesions of the ear among them ought to be much more often in the category of occupational accidents than of occupational diseases. In addition, the violent disturbances which occur from the deflagration of explosives singularly complicate the principle of the problem. Hence, it would perhaps be wise to limit the subject to industrial noises, properly so called, which are far more frequent. In return, it would be useful to compare the influence of vibrations where the noise is dominant, with the action of vibrations when shaking is the principal cause of trouble.

There are a great number of workers on trains, trams, and vehicles of all kinds, whose whole bodies are for many hours exposed to an energetic vibratory shaking, without which, however, the noise to which these workers are exposed would still be considered as excessive. Whatever the value of these previous remarks may be, let us examine the main sources of information at our disposal.

Castex, in 1897, speaking of engine drivers and stokers, pointed out the harmful influence of vibration: "shaking acts on the labyrinth and causes sclerosis, as

seen in the occupation of hammering." This is the conclusion, aptly expressed, to which Wittmaack came in his remarkable experiments, begun in 1903, on both ears of ninety guinea-pigs. Six guinea-pigs were subjected night and day, without interruption, to the noise of an electric bell, freely suspended above their cage. The animals were killed in succession after 5, 10, 20, 30, 40 and 60 days, and no lesion was found in any part of the auditory apparatus. This negative result gave rise to the idea that ear affection caused by noise must be due to something more than the simple transmission by air. He therefore modified his experiments in such a way that the vibrations of the electric bell were communicated to a tin plate on the floor of the cage. Very different results were then obtained; rapid emaciation of the animals was observed and two died after 14 days. Controlled experiments led to the same results and although, as before, the middle ear of animals killed after various intervals appeared intact, the nerve terminals in the cochlea, especially the organ of Corti, were degenerated. Analogous experiments, in which sufficient rest was allowed to resemble the normal conditions of human industry as far as possible, furnished similar results. Wittmaack tried also the influence of other noises, especially that of a whistle, as well as air disturbance caused by firearms. As a conclusion to his researches, he admits the preponderating influence of vibrations of solid substances on lesions of the ear, due to sounds, and he calls attention to the fact that among workers most frequently afflicted with occupational deafness one finds nearly always the possible transmission of vibrations by the bony skeleton, especially among blacksmiths, in whose work they are transmitted by the arm. In noisy factories the constant vibration of the ground is frequently observed.

According to Peyser, Wittmaack's first statement is of minor importance; the second on the other hand is of capital interest. The elasticity of the soft parts and articulations of the wrist and of the arm appeared to him to be a good non-conductor while the heavy body of the worker resting on vibrating ground, and especially the bony frame, from feet to head, would be favorable conductors for the transmission of vibration. An intermediate condition would be that of boiler riveters, who support their mechanical hammers by propping their elbows against their chests.' In corroboration, Peyser cites the authority of Friederick of Kiel, who thinks that the deafness of naval officers is at least partially attributable to vibrations of the ship during firing. Finally, with the object of studying the influence of conduction almost exclusively by air, Peyser examined the builders of hulks made of curved iron sheets which have to be riveted. During construction the hulk is placed on the ground, with the keel in the air, and supported on wooden blocks which rest on a mass of concrete 30 centimeters thick. The worker crawls under this metallic arch and proceeds to rivet by means of percussion hammers worked by compressed air. Of twelve workers engaged for two years at this work, none had become hard of hearing at the time the examination was made. Peyser concludes that this confirms the theory of Wittmaack on the influence of vibrations. Neither the number of observations, however, nor the length of time of service allow final conclusions to be drawn. Peyser concludes with the following statements:

1. Continual, but moderate noise, exclusively transmitted by air, has little or no action on the organ of hearing.

2. Short, but intense and shrill sounds, especially when repeated, injure the organ of hearing in a temporary or a permanent way.

3. Simultaneous conduction of noise by air and by the bony skeleton, and above all by the vibration of the ground, affects hearing finally and seriously.

Everyone does not admit the opinions of Wittmaack and Peyser. Reinking of Hamburg, at the last German Congress of Otology, made a communication tending to show the importance of the harm of air conduction. Delsaux could not agree entirely with Reinking concerning the minor importance of bone conduction and rightly put forward a statement, easy to prove, that it was not sufficient in normal conditions to stop up the nose, mouth and ears in order not to perceive any longer at a meter's distance words uttered in a high voice. One must admit in this case that sound is transmitted by way of a solid substance. On the other hand, Delsaux observed that the statements of Coosemans on "beetlers" in a linen factory contradict the conclusions of Wittmaack and Peyser. In fact, Coosemans has not found really serious lesions among workers whom he has examined and who were subjected at the same time to a muffled sound and to continual vibrations of the ground. He concludes that: (1) Every noisy trade is not necessarily harmful to hearing. (2) In order that it may be harmful, it is necessary (*a*) that the worker should be predisposed to affections of the ear, by the presence of lesions in the nose or pharynx; (*b*) that the noise should be intermittent; and (*c*) that it should be of a relatively high tone.

From the foregoing, it must be concluded that a certain amount of doubt still exists as to the extent of harmfulness of transmission of sound by air. Let us hope that future research may procure definite results on this point so important to industrial hygiene.

Prophylaxis

Choice of Worker. — Only young people fitted to undergo the normal consequences without damage should be allowed to work in noisy industries. Young persons with ear affections or predisposed to them by lesions in the neighborhood of the ear should be prohibited. This conservative method must, however, be used with great prudence. Statistics show that the number of persons with deficient hearing is considerable. According to Ely, 8.5 per cent. of conscripts were refused for this reason — a percentage which represents only the worst cases. Weill reports 30 per cent. of 5,905 children, whom he examined, as hard of hearing; Moure reports 17 per cent. out of 3,588; Bezold reports 20.75 per cent. out of 3,836, with ear trouble; Lausi shows 10.8 per cent. of deaf scholars; Sexton 13 per cent.; Gelle and Von Riechardt 22 per cent.; Ostman 36 per cent.; Nager 40.3 per cent.; Röpke 23.6 per cent.; Cronenberg 44.1 per cent.; Hansberg 50 per cent.; Felix 31 per cent.; Courtade 37.5 per cent.; Malherbe and Stackler 35 per cent. If these large numbers of deaf or partially deaf children were excluded from noisy industries, factories would soon be empty, for other groups of sick or puny children would also have to be excluded, one for deficiency of vision, another for poor development, and another for some physical disability. Also the law of work is universal and the weak and infirm must work for their living; but as a defect such as an ear lesion may be an indication of a more general disease, those who are excluded from noisy industries because they are partially deaf may find that they are refused entrance to any work at all. Great discretion must therefore be used, and only those most liable to harm should be prevented from entering the most injurious industries. This tolerance, however, requires a safeguard in the form of periodic medical supervision of young persons. In the same way it will be necessary to have a methodical periodic examination of the ears of adults working in noisy industries. At first one would imagine that an essentially defective ear would be an indication that the subject

should not work in a noisy atmosphere. But if Eicken and de Hoessli are correct in their assertions that the chains of ossicles conduct sound and do not damp it, as Zimmerman thinks, in certain circumstances a state of relative deafness, while not advantageous, would at least be harmless in certain industries where there is a loud or rackety noise.

When choosing workers for a noisy industry (and in doubtful cases this should be done by an ear specialist), the doctor must keep in mind the other peculiarities of the industry. For instance, a deaf man is more exposed to accidents in the vicinity of belts, gearing, etc., because very often when a machine is going wrong an unusual sound is emitted which acts as a warning. In the same way workers with alterations in the auditory apparatus associated with vertigo and loss of sense of space should not be exposed to falls from heights, such as from scaffolding, timber works, or bridges. In the medical examination a fixed unit of measurement should be employed throughout the country, so that absurd and unfair situations may be avoided; better still, there should be international uniformity to enable us to meet hostile criticism on prophylactic measures. At present, tests of hearing lack uniformity and even precision; the whispered voice, the murmured voice, the voice of conversation and the tick of a watch are very variable quantities. Still, if judiciously employed, these simple methods seem to suffice in ordinary examinations. A definite criterion is, however, needed for determining whether or not a more complete examination by an ear specialist is desirable.

As a means of securing uniformity in ear examinations, the following methods of estimating hearing in terms of the distance at which a watch is heard by the normal ear have been proposed:

1. Let M be the distance at which a watch is heard by a normal ear;

Let d be the distance at which a watch is heard by the examinee;

Let A be the auditory acuity of the examinee;

Therefore $A = \frac{d}{M}$;

Therefore, if M is 1 meter and d is 10 centimeters, $A = 0.10$ meter.

2. Let D be the maximum distance at which the normal ear hears the instrument of measurement;

Let d be the maximum distance for the ear examined;

Let A be the auditory acuity of the examinee;

Therefore $A = \left(\frac{d}{D}\right)^2$ since the intensity of sound is in inverse proportion to the square of the distances.

Ear specialists must aid us in drawing up examinations which will be uniform as to tests, signs and terms, and must determine for us the best methods to use, and at precisely what stage hearing is sufficiently diminished (*a*) to warrant refusing a young person work after a complete ear examination; and (*b*) to require an examination by an ear specialist of workers (young persons or adults) employed in noisy industries. It will be the particular field of ear specialists to do research on "the sense of space" and "the organ of equilibrium," and on such diseases as nystagmus, while the factory doctor can limit himself to finding the degree of vertigo or incoordination by the ordinary clinical means, and can pass on to the specialists the most interesting patients.

Individual Means of Protection. — The means of self-protection tend to muffle sound, and plugs of cotton wool and covering pads, and especially helmets and similar apparatus, are makeshifts disliked by the workmen on account of their weight and pressure, and because they are contrary to their habits. Such objects are often a hindrance to hearing orders and are also a cause of accidents, as they diminish the perception of unusual sounds or cries of appeal from fellow-workers in danger. They must therefore be reserved for special cir-

cumstances where it is impossible to do without them, and as these circumstances are rather numerous, it is necessary to make a detailed examination of the procedure to adopt. As regards the ear plug there is no agreement on the best method of application. Should it be slack or compressed into the ears or should the ear be stopped as completely as possible by a tight plug impregnated with an oily substance? Ignorance on this subject is due to the uncertainty in regard to the respective rôles played by air and solid substances in sound transmission.

It is certain, however, that as far as fatigue is concerned the vibrations of the soil are an important, harmful factor. Hence, the use of anti-vibratory footgear or mats is to be recommended in all cases. An individual method, frequently extolled, is change of work, but this can easily be carried too far. Although excellent in itself when recommended for workers in a particularly unhealthy trade, it loses all its value in a well-defined trade. Take, for instance, the case of a flax spinner. Her work is of a special kind, requiring an apprenticeship of from three to four years at least, and consequently commands relatively high wages. What would a spinstress do if she were put to winding or reeling? But if a change of occupation is often impossible, a change of place in the same occupation is often easy, and with differences of intensity, resonance and height of noise in various parts of the same room or in different departments or buildings of the same industry, it is advisable and possible by a simple change of position to improve conditions for a susceptible person.

Protective Measures Applicable to Working Conditions. — Extensive and painstaking researches should be made in order to discover the best means of lessening industrial noise. The origin, intensity, height and rhythm of noise, the local circumstances which increase it, the vibrations which accompany it, etc., must be examined in detail. It is necessary to reduce the intensity as well as height and resonance. Among causes which aggravate are carelessness, lack of room, wrong use of apparatus, lack of upkeep and repairs, abuse of glass partitions, insufficient natural ventilation. But if it is true, as is sometimes claimed, that the internal ear is organized in such a way that each of its parts corresponds to a sound of definite height, it would be of value to vary as often as possible the tone of sound in a factory, and this is practicable in many cases. It has been observed that a sudden intermittent, and more or less irregular noise is more disagreeable to the ear, other conditions being equal, if produced in a quiet atmosphere than in a noisy one. Here we have practically the action of the natural organic defences still unknown as regards the ear. It is useful at times to compare certain machines making a continuous moderate noise with those making a loud noise when thrown out of gear. But before we can successfully apply prophylaxis to objects, we must know how far air conduction is harmful to the ear. If it were shown to be powerless to create alone a serious organic ear lesion, the practical means to apply would be principally against vibrations, and it would be necessary to have special regulations for the supporting structure of machines and foundations of factories, special platforms for the use of workers, etc.

Conclusions

1. It is desirable that careful observations be made in order to remove the existing uncertainty in regard to the following points:

(*a*) Are lesions due to noise so localized that high and deep sounds act on different parts of the cochlea?

(*b*) Is air conduction in itself sufficient to cause in time lesions of the internal ear?

(*c*) What are the extreme limits of deficient hearing compatible with work in a noisy factory without examination by an ear specialist?

2. An international commission composed of doctors having access to all the factories of the country ought to decide the basis of an inquiry into industrial sounds, for the purpose of preparing a detailed account of the principal noisy industries.

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THE REHABILITATION OF EMPLOYEES: AN EXPERIENCE WITH 1,210 CASES *

FREDERIC S. KELLOGG, M.D.

Physician, Western Union Telegraph Company, Pittsburgh, Pa.

ALTHOUGH the custom of making a physical examination as a preliminary to employment has become very common in recent years, there has grown up on the part of the employees a great deal of opposition and even hostility to this requirement. The object of the work here described has been to extend and make practical use of these examinations for the reconstruction of the employee — a procedure by which we believe that immense gains, both economic and in point of health, will be secured, and a kindlier feeling established.

The subject of salvage in general has become a matter of vast and recognized importance and the savings thus secured are enormous. We may, for example, see this process being carried on daily in the disposal of city waste: A broad, endless belt carries the waste down a long room. Workers on either side take off various articles for reclamation, and what is left is then swept on to the furnace. If, instead of city waste, this endless belt were carrying men and women, more or less disabled, and if, instead of ordinary workers, there were stationed by the sides physicians and specialists, would such wholesale human salvage be possible? Or would it be better merely to make a selection here and there of the best?

The results submitted in this article were secured from the analysis of 1,210 examinations made among the employees of a large department store. There are in all 2,000 employees in this establishment, 85 per cent. of whom are women. The average age is 27 years. The method of medical service in use in this store has been fully described in an earlier paper,† and therefore it is enough for the present to say that the physical examination has been supplemented by reports from specialists or from laboratory experts whenever such reports were needed. The general physical condition of these men and women, as disclosed by the study of the examination records, is shown in Table 1, new employees and old employees being grouped separately by way of comparison. In Table 2 the workers are arranged in groups by decades, in order to show more clearly the progressive deterioration suggested by the figures in Table 1. From the schoolchildren group to the group of workers over 40 years of age there is a steady deterioration from 75 to 99.3 per cent., the causes of which, in the experience of this service, are as follows: infection from fellow employees, persistent bad hygiene, and neglect.

TABLE 1. — DISTRIBUTION OF DEFECTS IN OLD AND NEW EMPLOYEES COMPARED

Class	Total Number Examined	Average Age	No Defects	One Defect	Two Defects	Over Two Defects	Percentage Defects
New employees applying for work	532	23½	14	78	152	288	97.3
Old employees	678	27	7	113	217	341	98.9

As to infection, it may be said that in the examinations analyzed the following diseases have been found: scarlet fever, diphtheria, measles, whooping cough, impetigo

* Received for publication Oct. 10, 1921.

† F. S. Kellogg: Medical Supervision of Employees. Penn. Med. Jour., 1920, p. 667.

contagiosa, scabies, pediculi, gonorrhea, syphilis, pneumonia, erysipelas, tuberculosis and an immense number of cases of diseased tonsils, acute and chronic, and an equally large number of foul teeth and

TABLE 2. — DISTRIBUTION OF DEFECTS BY DECADES

Group	No Defects	Defective	Per Cent. Defective
Schoolchildren	....	...	75.0
Under 20 years	17	500	96.7
20 to 30 years	10	371	97.4
30 to 40 years	2	167	98.8
Over 40 years	1	142	99.3

septic mouths. Infection is very real and ever present; yet medical inspection has been limited to the schools.

Bad hygiene — that is, bad habits which will cause disability in time — is very common. Out of 425 cases which were investigated 359, or 85 per cent., were instances of bad hygiene. (Hygiene here does not include housing.) Neglect is even more common, indeed it is often the rule, as is evidenced by the fact that none of the forty-two cases of tuberculosis noted among the employees examined was on treatment, and also by the habitual disregard of treatment as shown by the figures given later in this paper (see Table 4).

The gravity of the defects noted in the examinations under discussion can be seen by reference to Table 3, in which are given the requirements in time for the rehabilitation of these employees. In contrast to the requirements and needs of these cases are the facts as to the actual treatment which the patients receive. The facts are ascertained as follows: On the completion of an examination and after reports from specialists have been received, it has been the custom to refer the patient for treatment to a hospital or to a specialist. In order that authentic reports of treatment may be received, the patient is given a report card with a stamped and addressed envelope. If treatment is secured, the report is received and noted on the patient's health record. If the report card is not returned, the patient is called again to the office and his case is followed up until he has received proper treatment. The amount of follow-up work needed is instructive: There were thus given to patients 1,054 report cards, after a complete physical examination, frequently supplemented by a careful examination by a specialist. The results were as follows:

Number securing treatment without follow-up work	62
Percentage securing treatment without follow-up work	5.9
Number who had to be called to office repeatedly	992

If, after a full examination and with expert advice, only 6 per cent. are led to secure treatment from competent hands,

TABLE 3. — REQUIREMENTS IN TIME FOR TREATMENT

Requirements	Number of Cases	Per Cent.
No stopping of work required	473	39.0
From 1 to 10 days of hospital care	573	47.3
From 10 days to 1 month at hospital	107	8.8
More than 1 month at hospital or sanatorium	55	4.5
Incurable and unable to work	2	0.1

what percentage would seek treatment when left entirely to their own initiative — the condition of general practice? Certainly it would be much less than 6 per cent. And of this small number what per-

centage would place themselves in competent hands? Or, being fortunate enough to find themselves in good hands, how many would remain on treatment long enough to secure any permanent benefits? It is evident that constructive treatment, such as is necessary for the rehabilitation of these employees, exists, if at all, in only a very small fraction of cases, and the progressive deterioration of the employee which has been shown is evidence of this fact.

The most impressive single fact brought out by the present study is the almost universal neglect of life and health. And yet the only means used at present for the reclamation of the disabled employee is the treatment which he secures upon his own initiative. The plan of leaving the sick or disabled employee to his own resources and trusting to his initiative is, therefore, a failure. If anything is ever to be done for the employee, we have, then, as an alternative, medical supervision, either by the company or by the state.

Experience with Medical Supervision

The experience here given covers a period of about two years, and includes a very great variety of diseases and disabilities. Treatment has not been made compulsory except in cases of tuberculosis and contagious diseases, including veneral diseases. Moreover, a case is considered and counted as having been treated only when the patient has been placed in a hospital, or in other thoroughly competent hands, and a report has been received on one of the cards already mentioned.

To report all the diseases and disabilities occurring among the employees of the department store under consideration would require an unduly long list. A few classes of diseases have, therefore, been selected in order to show the percentage of cases securing treatment. (Tables 4 and 5.) The low percentage attained in certain cases, such as diseases of the nose and throat, is to be explained by the fact that a very large number of operations have been recommended. Many of the cases which have not been treated as yet will, as a result of further work, have their defects corrected. It is to be noted, also, that although only forty-two cases were diagnosed positively as tuberculosis, there were 141 cases of suspected tuberculosis. Many of these, seventy-three in all, left the service of the company without allowing a careful study of their cases to be made. If all these cases had been carefully studied, it is certain that there would have been many more cases diagnosed as positive tuberculosis.

Although the general average of cases treated is not so high as we would hope to have it or so high as we expect to have it in

TABLE 4. — CASES TREATED UNDER MEDICAL SUPERVISION

Disease	Number of Cases	Number Treated	Per Cent. Treated
Diseases and defects of eyes	313	117	37.3
Diseases of ears	75	31	41.3
Diseases of nose and throat	691	91	13.1
Bad teeth	717	176	24.5
Diseases of digestive tract	94	24	25.5
Orthopedic (employees stand at work)	507	18	3.5
Diseases of skin	67	24	35.8
Gynecological cases	185	43	23.2
Appendicitis	11	7	63.6
Diabetes	2	2	100.0
Diseases of nervous system	6	3	50.0

the future, it is to be noted that it is about 19 per cent. more than it would have been without medical supervision. And however earnestly we may desire a higher percentage of cases placed on constructive

TABLE 5. — TREATMENT COMPULSORY

Disease	Number of Cases	Number Treated	Per Cent. Treated
Genito-urinary diseases	12	10	83
Syphilis (5 cases untreated) .	6	5	83
Tuberculosis (diagnosis positive)	42	30	71
Suspected tuberculosis (diagnosis not made)	141	....	....
Contagious diseases	6	6	100
Pregnancy (including 1 case of toxemia of pregnancy)	6	6	100
Total defects noted	2,906	577	19.8

treatment, we cannot secure these best results without educating the employees. They must be taught new and higher ideals of health. The very existence of a medical service, such as the one considered in this report, is the best way to teach these ideals. The constant contact with the medical department and the transformation effected in the lives of many of the patients will teach lessons which can be learned in no other way. The relief of recurring headaches and of the exhaustion of chronic ill health, the rejuvenation of the consumptive, the development of ability and talent blighted by disease — these benefits will give new standards of health, and secure hearty co-operation on the part of the employee.

Conclusions

There is a progressive deterioration of physique in the group of employees here studied and presumably among working people in general. This deterioration is found to be due to infection from associates, to persistent bad hygiene, and to continual neglect.

The initial or sporadic examination cannot supply a healthy body of employees nor can it arrest this strong tendency to deterioration.

Medical supervision offers an effective means of securing the rehabilitation of employees, and salvage of large groups of men and women is thus practicable.

The time, therefore, is surely past when employer and physician, content to make a selection here and there, can watch with indifference the endless stream of more or less disabled men and women sweep by.

TRINITROTOLUENE POISONING — ITS NATURE, DIAGNOSIS, AND PREVENTION

Continued

CARL VOEGTLIN, CHARLES W. HOOPER, AND J. M. JOHNSON

From the Division of Pharmacology, Hygienic Laboratory, U. S. Public Health Service

Field Investigation

THE principal purpose of the field investigation was to apply the knowledge gained from the study of T.N.T. poisoning in animals to the conditions prevailing in the factories. This work was done in a large shell-filling plant employing from 7,000 to 8,000 workers, and was made possible through the co-operation of both the management and the workers. The workers were employed in three shifts of eight hours each. The general sanitary conditions of this war settlement, such as housing, sewage disposal, water and food supply, were excellent. A hospital with a competent staff of physicians and nurses looked after the sick workers. On account of the high wages paid, the labor turnover was not large, a fact which made it possible to examine workers who had been exposed to T.N.T. for a long time. The workers of each factory unit were sometimes shifted from one job to another, but on the whole a considerable number were continuously exposed to T.N.T. The following brief remarks are intended to familiarize the reader with the conditions under which the T.N.T. worker is exposed to the poison.

Manufacture of High Explosive Shells

The manufacture of high explosive shells varies with the type of explosive used. At the beginning of the war, T.N.T. was extensively used as the main charge. With the tremendously increased demand for these shells, it became necessary to supplement the deficient supply of T.N.T. by using a mixture of ammonium nitrate and T.N.T., commonly called amatol.

If T.N.T. alone is used, it is melted in large steam kettles at a temperature of about 85°C., and the molten explosive is then poured into the shells. Amatol is prepared by mixing from three to four parts of dry ammonium nitrate with T.N.T. at a temperature of approximately 90°C. The mixture, while still warm, is pressed into the shells by machinery (extruding machine). In order to understand the process of filling, the following description of the various parts of a high explosive shell is here given.*

The *shell* proper is made of hollow steel and fits snugly into the top of the cartridge. The *bursting charge* is contained in the shell and consists either of T.N.T. or amatol. A circular opening in the top of the shell is threaded so as to allow the adapter and booster to be screwed down into it.

The *adapter* is a device holding a narrow tube which in turn contains a narrower tube. The two tubes together constitute the *booster*. The adapter and booster are loaded with a mixture of tetryl (tetranitroaniline) and T.N.T. The *fuse* which is loaded with a sensitive explosive (mercury fulminate) is inserted at the top of the shell. The fuse is not inserted at the filling plant, but is put in before the shell is fired. The bottom of medium and large caliber shells contains a mixture of T.N.T., ammonium nitrate and ammonium chloride. This mixture ("smokemix") is used to produce smoke for the purpose of range observations.

The method of filling the shells in use at the plant where this investigation was carried out is essentially the following: The

* See "Ordnance and Gunnery" by Tshappat, Wiley & Sons, 1917.

empty shells are first painted in the empty-shell room. After this they pass to the pouring house containing three steam kettles in which the T.N.T. is melted. These kettles are provided with a hood connected with a vertical ventilating pipe which passes through the top of the roof. The hood has a window which permits the filling and emptying of the kettle. The workmen on this job are exposed to T.N.T. fumes and dust. The molten T.N.T. is poured into large ash cans, from which the shells are filled by means of hand dippers. The T.N.T. in the shells slowly crystallizes. The crust which is formed on the top is broken up in order to prevent cavity formation. This work is usually attended to by women. After all of the T.N.T. has crystallized the shells are put on trays and moved on rails to the finishing room, where the booster cavity is formed. This last process is done by pouring T.N.T. around a steel form inserted into the top of the shell. After cooling, the form is removed and the cavity is blown out with compressed air. The finishing room contains a steam kettle of the same construction as those in the pouring room. Finally the booster, containing the mixture of T.N.T. and tetryl, is inserted into the top of the shell. The loaded shells are transferred to the stenciling room, where they are labeled, weighed, and examined. From the stenciling room the shells pass to the magazine.

The booster plant is separated from the filling plant. The mixture of dry T.N.T. and tetryl is pressed into the booster by means of hydraulic presses. Amatol was used as the main charge until two months before this work was begun.

Incidence of T.N.T. Poisoning

In the time at our disposal it was impossible to examine all T.N.T. workers in this plant. For this reason, 237 workers were selected at random and subjected to a thorough examination, special attention being given to the presence or absence of clinical manifestations of T.N.T. poisoning, such as cyanosis, icterus, and dermatitis. A specimen of urine was obtained from each worker, and this was examined for the presence of T.N.T. derivatives (Webster test), bile pigment and albumin. The blood was tested for its hemoglobin content by means of a Sahli hemoglobinometer standardized against a standard solution of hematin. The hemoglobin figures are therefore very reliable. The number and character of the red blood cells was determined. A white cell count and differential count were also made, and the number of nucleated red cells per 200 white cells counted. Information as to the length of exposure to T.N.T. and the type of work performed by each worker was obtained. The data pertaining to this work are compiled in the accompanying tables. Before proceeding to a discussion of these results, it is desirable to review briefly the work of other investigators interested in this subject.

Livingstone-Learmonth and Cunningham (28) relate their experiences in a shell-filling plant in Great Britain and call attention to the frequency of poisoning among thirty-six women workers as determined by clinical symptoms. They also report the blood and necropsy findings of a case of toxic jaundice. The blood in this case showed 4,400,000 red corpuscles, 9,320 white cells, 60 per cent. hemoglobin, absence of methemoglobin and nucleated red cells, no abnormalities in white cells.

Panton (24) examined fifty T.N.T. workers, some of whom had mild symptoms but were perfectly fit for work, with special reference to the blood changes. He stated that the red cells and hemoglobin were not adversely affected, with the exception of a slight degree of poikilocytosis. A moderate leukocytosis with a relative increase in the polynuclear neutrophils was noted in many cases. The blood serum often contained an

abnormal amount of bile pigment. Panton furthermore examined twenty-eight cases of toxic jaundice and six cases of so-called aplastic anemia. In the former group only four cases showed blood changes, these being characteristic of aplastic anemia. Panton suggests that moderate doses of T.N.T. might lead to a stimulation of the blood-forming organs.

Stewart (29) reports fourteen cases of toxic jaundice, in some of which the blood revealed an anemia of various grades. In nine cases a neutrophil leukopenia with lymphocytosis was noted.

Smith (30) examined twenty-five workers exposed to T.N.T. dust. A few showed slight cyanosis and complained of abdominal pains, but were otherwise perfectly fit for work. The lowest hemoglobin estimation was 75, and the red cell count was never below 4,400,000. No abnormality was noted in the character of the red cells. Most of the cases showed a moderate leukocytosis and increase in polymorphonuclear neutrophils. The platelets appeared normal.

Harrington (31) and Gregorson and Taylor (32) also report a small number of cases of T.N.T. poisoning.

Recently a paper appeared by Minot (33) in which the blood changes found in 233 T.N.T. workers are reported in great detail, as follows:

> Red cell abnormalities were found to be very frequent. The most interesting abnormality was the frequent finding of fragmented or fragmenting red cells which have a definite histologic character. These cells appear to afford evidence of a rapid increased destruction of the red cells. Evidence shows that distinct increases of these cells are to be looked on as a significant sign of a considerable degree of poisoning; and probably when they occur in large numbers, they indicate some degree of toxic jaundice. Among other red cell abnormalities noted were the following: Polychromatophilia occurred in 83 per cent. of the cases, often to a marked degree. Howell-Jolly bodies, stippling and blasts were found, and increased numbers of reticulated red cells. The red cell count averaged in the mildest cases 4,500,000, and in the severest 3,800,000. It was found that there was usually a definite relationship between the total amount of red cell changes and the symptoms. Methemoglobin or some form of changed hemoglobin is apparent in these cases.
>
> The white blood cells do not furnish as much information concerning the workers' condition as do the red cells. Slightly increased white cell counts were common. The observations showed that an individual may become distinctly and severely poisoned with a normal, or an absolute or relative increased lymphocyte count, or with an increased or normal polymorphonuclear count. However, lymphocytosis is to be looked on as an undesirable sign, but does not necessarily indicate that significant poisoning will occur or is occurring, except when there is a leukopenia. Slight eosinophilia (more than 5 per cent.) occurred in 10 per cent. of the cases. It was more common in cases with slight symptoms than in those with marked.
>
> The blood platelets were usually slightly increased. Their diminution was observed twice and in both cases there was a relative lymphocytosis. Such a condition should certainly be regarded as evidence of a severe effect on the marrow, indicating aplasia. Webster's test for changed trinitrotoluene in the urine was found to be less valuable than blood examination to indicate the worker's condition.

Minot (33) (34) does not give much information as to the change in hemoglobin content of the blood. The few hemoglobin estimations referred to were made by the Tallquist method, which is very unreliable.

In its final report the Health of Munition Workers Committee of the British Ministry of Munitions (35) makes the following recommendations concerning the detection of the milder forms of T.N.T. poisoning:

> . . . Care must be taken to avoid confusion with digestive disturbances due to other causes. Accounts given by patients may be unintentionally misleading. The yellow staining which normally occurs with T.N.T. cannot be taken as in itself a sign of poisoning. The following points are the more important indications of T.N.T. poisoning:
>
> (*a*) Pallor of face and an ashen grey colour of the lips, tending to disappear if the worker becomes excited, as by medical examination. Sometimes the lips and tongue are purple in colour; the tongue is generally free from fur.

(*b*) The character and situation of the stomach pains.

(*c*) The presence of constipation and stomach distention.

The literature, therefore, shows that, with the exception of Minot, all writers rely principally on the presence of clinical symptoms for the diagnosis of T.N.T. poisoning. We cannot share this view, as our work has clearly shown that marked blood changes may be present in some workers in spite of the fact that they do not exhibit any cyanosis, pallor, or icterus. Table 1 reveals the significant fact that 72.5 per cent. of the workers showed an anemia of various grades. These cases are grouped into three classes as follows: (1) slight anemia, men with less than 84 per cent. hemoglobin or a red cell count below 4,000,000, and women with less than 80 per cent. hemoglobin or a red cell count below 3,700,000; (2) moderate anemia, workers with a hemoglobin content of from 60 to 71 per cent.; and (3) severe anemia, workers in whom the hemoglobin was below 60 per cent. According to Table 1, most of the anemia cases belong to the first and second groups, and only one case revealed the presence of a severe anemia. The red cell count of the anemia cases is very often normal or even above normal. The red cells of these cases are, however, abnormal, showing anisocytosis and poikilocytosis. This relatively high number of red cells is due to fragmentation and proves that a red cell count alone, in the absence of a hemoglobin estimation, is a very unreliable diagnostic index. Nucleated red cells were found in the circulating blood in 18 per cent. of the anemia cases. As regards the leukocytes, 4 per cent. of the cases with anemia showed a leukopenia, 22 per cent. a leukocytosis (count above 10,000), and 49 per cent. a relative lymphocytosis (mononuclears above 40 per cent.).

TABLE 1. — CLASSIFICATION OF CASES WITH ANEMIA

[Data compiled from an examination of 149 male and 88 female T. N. T. workers.]

Degree of Anemia	Number of Cases					Hemoglobin in Per Cent.				Erythrocyte Counts				Cases with Poikilocytosis or Anisocytosis	Cases with Nucleated Red Cells in Circulation	Leukocytes		
						Males		Females		Males		Females						
	Per Cent of Workers Examined	Males	Per Cent. of Males Examined	Females	Per Cent. of Females Examined	Average	Extremes	Average	Extremes	Average	Extremes	Average	Extremes			Cases with Count below 5,000	Cases with Count above 10,000	Cases with Relative Lymphocytosis
														%	%	%	%	%
Slight	50.2	80	53.7	39	44.3	79	97–71	76	91–71	4,306,000	5,736,000 2,928,000	4,210,000	5,440,000 2,888,000	38	14	2.5	23	46
Moderate	21.5	32	21.5	19	21.6	67	70–61	66	70–62	4,181,000	5,200,000 3,488,000	4,064,000	4,704,000 3,224,000	41	22	8.0	22	61
Severe	0.4	1	0.7	..	..	57	57	..	..	2,936,000	2,936,000	....	....	0	0	..	100	100

Both sexes show approximately the same percentage of anemia cases, a fact which indicates that sex has no influence on the susceptibility to T.N.T. poisoning. The same holds true in regard to the relation of the age of the workers to the susceptibility to anemia, as the latter appears in young, middle-aged, and old persons, the average age of the workers included in the three grades of anemia being approximately the same. (See Table 2.) In passing, it should be mentioned, however, that the British reports refer to the greater susceptibility of persons under 18 years of age. We were unable to verify this observation as the factory regulations prohibited the employment of persons below 18 years of age.

There is no consistent relation between the time of exposure and the susceptibility to anemia, a fact which is probably best explained by variations in the individual susceptibility of the workers to T.N.T. poisoning. It will be recalled that a very marked difference in individual susceptibility was also observed in dogs, and there is no reason to doubt that it may likewise occur in man. Moore (7) attributes this difference in susceptibility to differences in the permeability of the skin to T.N.T. We believe that this factor may partly account for these differences, but not entirely. It cannot be denied that the skin of various individuals shows a considerable variation in permeability to certain poisons. This was very well proved in the case of a number of war gases. It is to be kept in mind, however, that it was shown in the previous section of this report that dogs exhibited a marked difference in susceptibility, even when differences in the absorption of T.N.T. were completely excluded. Under these conditions the variation in individual susceptibility is very likely due to differences in the methods of dealing with the poison on the part of the body, in the manner indicated in the experimental section.

Only 48 per cent. of the anemia cases showed the presence of cyanosis of the lips. This observation is in conformity with the observations made on dogs with chronic T.N.T. poisoning. Here it was also shown that cyanosis of the oral mucous membrane is often absent in spite of the presence of a moderate to severe degree of anemia. Pallor of the skin was noted in 39 per cent. of our cases showing anemia.

A considerable number of the workers without anemia exhibited certain blood abnormalities and the presence of cyanosis or pallor. (See Table 3.) This would indicate that T.N.T. was absorbed by these workers, but obviously not in sufficient quantity to produce an anemia or toxic jaundice. In these cases blood regeneration was able to overcome any increased blood destruction caused by the poison.

TABLE 2.—RELATION OF ANEMIA TO AGE, TIME OF EXPOSURE TO T. N. T., AND CYANOSIS

[Data compiled from an examination of 149 male and 88 female T. N. T. workers]

Class	Age in Years		Time of Exposure in Days		Number of Cases with Cyanosis and Anemia			Number of Cases with Pallor and Anemia		
	Average	Extremes	Average	Extremes	Per Cent. of Total Number of Cases	Males	Females	Per Cent. of Total Number of Cases	Males	Females
Slight anemia.....	28	18–70	122	8–545	45	46	8	33	28	11
Moderate anemia	30	18–53	102	8–390	55	21	7	49	16	9
Severe anemia	20	20	24	24	0	0	0	0	0	0

The urine of these workers never contained even traces of bile pigment, and icterus was always absent. In no case did the urine contain sugar, and in a few cases only, a moderate amount of albumin was found. The urinary Webster test was made in a large number of cases and was nearly always positive. There was no relation between the intensity of the test and the anemia. The detailed account is therefore omitted. The Webster test has no diagnostic value beyond showing that T.N.T. is absorbed and excreted in a modified form. A few of the workers complained of shortness of breath and palpitation following slight exertion. Others complained of itching of the skin of the forearms and face, and in a few workers a typical papillar dermatitis was observed. The skin of the hands often shows a yellow staining due to

T.N.T. The hair of some workers assumes a reddish-yellow discoloration.

To sum up, it can be said that nearly three-fourths of the workers examined showed definite signs of poisoning. For the detection of poisoning the physician cannot rely altogether on symptoms, but he should also make a blood examination. Much valuable information can especially be gained from an accurate hemoglobin estimation. A standardized Sahli hemoglobinometer is recommended for this purpose.

Preventive Measures

In the manufacture of T.N.T. and in the filling of shells with this substance, it is almost impossible to prevent all contact of the workers with this poison. A certain amount of vapor is always formed in the heating of T.N.T., and unless rigid precautions are taken this vapor escapes to some extent into the workrooms, where it condenses to a fine dust which settles slowly. It is also impossible to prevent completely the spilling of either the molten or solid explosive, with the result that the floor, machinery, and the outside of the shells are more or less contaminated with T.N.T. Hence the workers may absorb the poison through the skin or the poison may enter the body with the inspired air. In this latter case part of the substance may be swallowed and absorbed from the gastro-intestinal tract. On account of the absence of a method for the determination of the absolute amount of T.N.T. absorbed by the skin of the workers, it is impossible to estimate the relative importance of skin absorption and absorption by the respiratory and gastro-intestinal tracts. Moore and his colleagues are inclined to attribute all T.N.T. poisoning to skin absorption. This view is altogether too one-sided, as the estimation of the air contamination made by Professor Phelps and Mr. Casselman of this laboratory plainly proves that under certain conditions the workers take in a considerable amount of the poison with the inspired air. For this reason it is safer to take the necessary precautions against both methods of absorption. The same position in regard to this matter is taken by the British Health of Munition Workers Committee in its final report.

Absorption of T.N.T. by Skin

In view of the importance attached to skin absorption in the production of T.N.T. poisoning, it appeared desirable to determine the skin area actually exposed to the poison.

Several hundred workers, both men and women, were examined by testing the skin of the various parts of the body with alcoholic sodium hydroxide (Webster's reagent) and noting the intensity of the color so obtained. This varied from a very deep purple to a negative finding, and differed considerably on the same body surfaces in different individuals. As a general rule the reaction is most intense on the palms of the hands and about the ankle region. Next in

TABLE 3. — BLOOD CHANGES AND SYMPTOMS IN WORKERS WITH AND WITHOUT ANEMIA

	Cases	Poikilocytosis or Anisocytosis	Nucleated Red Cells	Leukocytes			Cyanosis	Pallor
				Below 5,000	Above 10,000	Relative Lymphocytosis		
		%	%	%	%	%	%	%
With anemia	171	39	18	4	22	49	48	39
Without anemia	66	32	6	0	15	52	36	27

line comes the dorsal surface of the hand, the wrist, the foot below the ankle, the forearm, the neck, and the face, in the order named. The reaction is rarely positive on other parts of the body.

The skin area exposed to T.N.T. in female workers was as a rule not so extensive as that of male workers, which is due to the facts that the former are more particular in wearing clean overalls, underwear, and gloves, and that they bathe more frequently than the average male worker. This conclusion was reached from information volunteered by the workers, and from inspection of the change houses and living quarters.

The important practical point brought out by these tests is that the clothing and overalls protect the covered skin very efficiently against contact with the poison. The only exception in this respect concerns the ankle region. The poison gained access to this skin area on account of the fact that overalls of these workers did not cover the upper part of the shoes, and thus permitted T.N.T. dust to penetrate the stockings above the shoes. In order to avoid this the worker should be required to wear overalls which cover not only the legs but also the ankles.

The use of leather gloves seems to be of little protective value, as most of the workers remove them from time to time, thus allowing the inside of the gloves to become covered with T.N.T. Under these conditions skin absorption is probably favored instead of reduced, especially during the warmer seasons when excessive perspiration might aid it. The use of gloves should therefore be discouraged.

The British official reports refer to the failure experienced in the use of skin varnishes in the prevention of skin absorption. In several cases varnishes gave very unsatisfactory results. Dr. George F. White of this laboratory has experimented with a shellac castor-oil varnish which appears fairly satisfactory for this purpose, but its trial in the factory was impracticable.

Further work was done in order to discover an inexpensive, harmless, and efficient skin wash which might prove satisfactory in removing T.N.T. from the skin of the workers before they left the factory. It is obvious that such a skin wash might considerably reduce, possibly by two-thirds, the amount of T.N.T. absorbed by the skin, as the worker would no longer absorb the poison after leaving the factory. The regulations in this plant required that the workers should wash their hands and faces very thoroughly with soap and water after stopping work, and they were also advised to take a shower bath. Excellent wash houses were available for this purpose, but the instructions were only partially carried out. It was furthermore found that soap and water do not remove all the T.N.T. from the skin even after thorough and repeated washing. Numerous experiments were then carried out to determine the solubility of T.N.T. in various solvents. The most promising solvent seemed to be a 10 per cent. sodium sulphite solution. This wash was tested out on T.N.T. workers in the following manner:

Thirty-six workers volunteered for this experiment. They were asked to wash their hands and forearms very thoroughly, first with soap and water, and then with 10 per cent. sodium sulphite in water. The presence or absence of T.N.T. on the skin previous to and after the washing with soap and the sulphide was determined by means of alcoholic sodium hydroxide (Webster's reagent). The results are illustrated by Table 4. It is evident, then, that washing of the skin with soap and water removes only a relatively small portion of T.N.T. After washing in the sodium sulphite, however, the test for T.N.T. became negative in practically all cases except where the washing had not been very thorough.

In order to gain some information as to the actual amount of T.N.T. removed by the sulphite wash, the following experiment was carried out: Four T.N.T. workers were asked to wash their hands and forearms thoroughly with soap and water. After this they washed a second time in a liter of 10 per cent. sodium sulphite, care being taken to prevent spilling of the solution. The sulphite solution assumed a dark red color and was analyzed for T.N.T. in the following manner. The solution was acidified with dilute sulphuric acid and extracted twice with ether. The ether extract was washed twice with distilled water and the ether evaporated to dryness. The crystalline residue, after drying to constant weight, weighed 148 mg. and consisted of T.N.T. It is, therefore, evident that at least 37 mg. were removed from the hands of each worker.

The workers who used the sulphite wash were enthusiastic over the efficiency of this chemical for the removal of T.N.T. and made inquiries as to where they could procure it. The reason for the great interest on the part of the workers is that the deep red color which appears on the skin after treatment with sulphite clearly proves to the worker the presence of T.N.T. on his skin, and the fact that the color passes into the solution visualizes the removal of the poison from the skin. There is no objection to the use of the sulphite solution for washing the face and neck, as animal experiments have demonstrated that this solution has no injurious effect on either the skin or the eyes.

TABLE 4. — RELATIVE EFFICIENCY OF SOAP AND WATER AND SODIUM SULPHITE SOLUTION IN REMOVING T. N. T. FROM SKIN

No. of Worker	Webster Test before Washing			Webster Test after Soap and Water			Webster Test after Sulphite			Remarks
	Hands	Wrist	Forearms	Hands	Wrist	Forearms	Hands	Wrist	Forearms	
M. K. 471	++++	+++	+	++	+	+Sl	....	....	....	End of shift.
M. D. 647	+++	++	+	++	+	+Sl	....	....	....	" " "
L. I. 358	.....	.....	.....	++	+	.....	....	....	....	" " "
L. E. 543	++++	+++	++	++	++	+	....	....	....	" " "
M. K. 85	++++	++	+	++	+	+Sl	....	....	....	" " "
L. D. 314	++++	++	+	++	+	+	....	....	....	" " "
L. K. 401	.....	.....	.....	++	+	.....	....	....	....	Had been off T. N. T. two weeks; worked on day of test.
L. K. 192	++++	+++	+	+++	+	+Sl	....	....	....	End of shift.
L. I. 562	++++	++	+	+++	++	+	+Sl	+Sl	....	" " "
L. I. 488	+++	++	+	+	+Sl	.....	+Sl	....	....	Did not wash thoroughly.
L. I. 276	++++	+++	++	++	++	+	+Sl	....	....	" " " "
L. H. 615	++++	+++	++	++	+	+Sl	....	....	....	" " " "
X.	+++	++	+	++	+	+	+Sl	....	....	" " " "
X.	++++	+++	++	++	+	+	+Sl	....	....	" " " "
L. I. 591	.....	.....	.....	++	+	+	....	....	....	" " " "
L. I. 505	.....	.....	.....	+++	++	+	....	....	....	" " " "

Absorption of T.N.T. by Lungs and Gastro-Intestinal Tract

In order to prevent as much as possible the absorption of T.N.T. by the lungs and gastro-intestinal tract, the workrooms should eliminate the possibility of air contamination with T.N.T. In the factory in which this work was carried out, three operations exposed the workers to badly

contaminated air. First of all the melting of T.N.T. in the steam kettles led to the escape of a considerable amount of the vapor into the workroom as the kettle hoods were not provided with forced draft. The workmen engaged in melting were therefore breathing air more or less saturated with T.N.T. vapor, which, according to the analyses reported by Professor Phelps and Mr. Casselman,* contained 0.006 mg. of T.N.T. per liter. The worker would therefore breathe at least 16 mg. of T.N.T. during seven and one-half hours. Another operation which led to air contamination was the sweeping of the floors, which was done three times during the day while the workers were at work. The dust suspended in the air by means of this operation is very light and settles slowly. As the result of the sweeping, each worker would breathe in approximately 9.1 mg. of T.N.T. during a day. The third objectionable operation consisted in blowing out the booster cavity with compressed air. This was done very frequently in the finishing room, and the persons on this job may take in 2 or 3 mg. of T.N.T. with each breath. These serious health hazards could easily be eliminated by the use of exhaust ventilators for the melting kettles and an appropriate vacuum system for the cleaning of the floors and the booster cavity.

The figures given in the report of Professor Phelps and Mr. Casselman are convincing enough to emphasize the importance of preventing air contamination. The method used was much more accurate than the one used by Moore and his colleagues, a fact which explains the higher values thus obtained.

As a further precaution, the workers should be urged to wash their hands thoroughly before eating their meal during the working hours. The protective value of respirators has been tested out extensively in this country and abroad, and has been found to be very unsatisfactory.

This investigation, therefore, clearly proves the necessity of guarding the worker against absorption of the poison by the skin as well as by the lungs and gastro-intestinal tract.

Diet

In the first part of this paper attention was called to the relation between diet and T.N.T. poisoning. It was pointed out that dogs on a meat diet are more resistant to the action of T.N.T. than dogs fed on bread and milk. In view of this observation it was important to make inquiries concerning the diet of the workers.

The company operates two mess halls, one principally for women, the other for men. In both of these a fixed menu is served. There is also a "short-order" restaurant where the workers can choose their menu from a large variety of foods. The portions served in these mess halls are fairly liberal. The menus vary but little from week to week.

A relatively small number of the workers live in family cottages and procure their provisions from the company's commissary store.

It was evident that the diet of the workers was varied and that it included a considerable amount of meat, vegetables, cereals, bread, butter, and fruits. The good quality of the diet consumed by the workers may be one of the factors which accounts for the evident absence of severe T.N.T. poisoning in this plant.

Toxic Jaundice and Aplastic Anemia

The first cases of toxic jaundice attributed to T.N.T. were reported in 1915 by the medical inspectors of factories to the British home office, which in turn issued instructions to physicians to report all such cases. According to O'Donovan (36) there occurred in England, in 1916, 181 cases

* The report by Professor Phelps and Mr. Casselman will be published elsewhere.

with 50 deaths; in 1917, 189 cases with 44 deaths. In addition there were reported during this period 14 cases of aplastic anemia, these cases being regarded as representatives of another extreme form of T.N.T. poisoning. No statistics are available as to the prevalence of these two conditions in the United States. Martland (5) and Haythorn (37) report two fatal cases, giving also the pathological findings at necropsy. Hamilton (38) (39) reports 13 deaths from T.N.T. poisoning in the United States, but fails to state the nature of the clinical picture, whether toxic jaundice or aplastic anemia.

It is very significant that the occurrence of toxic jaundice and aplastic anemia in T.N.T. workers is relatively rare when it is considered that Great Britain alone employed over 100,000 persons in the manufacture of munitions. It is also to be remembered that the diagnosis of toxic jaundice depends largely on the icterus, which of course is not characteristic of this condition only, and the association of the worker with T.N.T. Syphilitic icterus, or true yellow atrophy of the liver, may occur in T.N.T. workers and may thus lead to a diagnosis of toxic jaundice. The same holds true for aplastic anemia, a disease which also occurs in persons not exposed to T.N.T. It is therefore possible that the figures given by O'Donovan are somewhat too high.

The question naturally arises as to why most of the T.N.T. workers should be immune to toxic jaundice and aplastic anemia. The following considerations may assist in the solution of this problem. From the results obtained in the study of T.N.T. poisoning of dogs, it is evident that T.N.T. often causes the appearance of a very severe anemia. The bone marrow of these animals is hyperplastic without exception, and for this and other reasons the anemia as observed in these animals cannot be regarded as a true aplastic anemia. The blood destruction was therefore attributed to a primary injury of the red cells leading to fragmentation and eventually to phagocytosis of the injured red cells by the phagocytic cells of certain organs. The examination of the T.N.T. workers has furthermore revealed the fact that a considerable number show a moderate anemia. Minot has also called attention to the fragmentation of the red cells in many T.N.T. workers.

We therefore believe that the available evidence clearly shows that the mechanism of the blood destruction caused by T.N.T. is essentially the same in dogs and in man. Previous writers on this subject insist, however, that T.N.T. anemia is caused by the toxic action of T.N.T. or some of its derivatives on the hematopoietic organs, especially the bone marrow. Our data do not permit us to exclude this possibility altogether, although they do show that T.N.T. anemia is essentially a phagocytic anemia. The bone marrow was examined only in six cases of so-called aplastic anemia in T.N.T. workers. The marrow of the femur was described as gray in one case, fatty with pink spots in two cases, and pale pink in two cases. Turnbull (40) from the microscopic examination of the bone marrow in one case, claims that it showed a relative excess of erythroblastic activity and a decrease in the number of megalokaryocytes; numerous plasma cells and large phagocytes containing pyknotic nuclei, erythroblasts, erythrocytes, and iron-containing pigment. It is possible to conceive that in the later stages of the anemia the function of the bone marrow may be seriously depressed on account either of the oxygen deficiency or of other metabolic abnormalities resulting from the severe anemia, or as the result of the direct action of the poison on this organ. We believe, however, that these factors are of minor importance in the production of T.N.T. anemia.

As to T.N.T. icterus, the experimental

work plainly shows that this condition may often occur in the absence of liver necrosis or atrophy, in which case the icterus is probably due to the inability of the liver cells to excrete the increased amount of bile pigment resulting from the destruction of erythrocytes. Some of the cases of toxic jaundice reported by Panton (24) may possibly be explained on this basis. The blood of these patients showed a normal hemoglobin content and red cell count. On account of these findings some writers explain T.N.T. icterus as being primarily due to the injurious action of the poison on the liver cells, a view which is not necessarily correct as it is quite possible to conceive that T.N.T. may lead to a considerable increase in red cell destruction and consequently bile pigment formation, without causing a reduction in the hemoglobin content or number of red blood cells. The hemoglobin content and red cell count are not an absolute index of the degree of blood destruction, as increased blood regeneration may temporarily compensate the increased disintegration of red cells. Some of Panton's cases which he observed for several weeks showed a gradual decrease in hemoglobin and the number of red cells, this finally resulting in the appearance of a severe anemia. It is very likely that in the early stages of the jaundice the increased blood destruction was compensated by regeneration, and that later on, when this compensation failed, the anemia appeared.

It is therefore possible to attribute the icterus in some of the toxic jaundice cases to the increased blood destruction caused by T.N.T. In other cases, however, the icterus is associated with a marked reduction of liver dullness during life, and at necropsy the liver shows extensive necrosis and atrophy, which, according to Turnbull, Haythorn, and others, cannot be distinguished from acute yellow atrophy. The liver was examined in thirty of these cases and in all a greater or less degree of acute yellow or red atrophy was present. The liver cells of some areas were completely destroyed. Some observers also found a moderate amount of cirrhotic change. It is difficult to determine whether or not T.N.T. alone is responsible for these liver changes. We are rather inclined to explain these cases by assuming that certain preexisting pathological conditions affecting the functional capacity of the liver, such as cirrhosis, syphilis, alcoholism, etc., may predispose some T.N.T. workers to toxic jaundice in an abnormal degree. Under these circumstances, it is possible to conceive that T.N.T. or its reduction products may exert a more deleterious action on the liver cells than in persons with normal livers. This explanation would account for the fact that in numerous experiments with dogs it was impossible to produce even the slightest degree of liver atrophy, and this in spite of the fact that these animals are highly susceptible to necrosis of the liver when exposed to poisons with a more or less specific action on the organ, such as chloroform, phosphorus, and arsenicals.

The fact that toxic jaundice sometimes appears in T.N.T. workers several weeks after their removal from all contact with T.N.T., agrees with the observation made on dogs, *viz.*, that T.N.T. is very slowly eliminated from the body, and therefore continues to exert its toxic action for a long period of time.

If the correctness of these considerations is taken for granted, the prevention of toxic jaundice and so-called aplastic anemia in T.N.T. workers should concern itself principally with the elimination of all persons with evidence of liver disease and anemia from contact with T.N.T. Moreover, all T.N.T. workers should be frequently examined by the factory physician, special attention being given to the occurrence of a slight icteric change of the conjunctiva or skin, the presence of this symptom being regarded as sufficient reason to put the in-

dividual on work where he is no longer exposed to T.N.T. An accurate hemoglobin estimation should also be made on each worker every week, or at least every two weeks. A nurse or specially trained laboratory assistant could easily attend to this work. Any workers with icterus or severe anemia should be admitted to a hospital. The treatment should consist first in the removing of all T.N.T. from the body surface by means of a 10 per cent. sodium sulphite solution. The anemic patients should receive a nutritious diet containing a fair amount of fresh meat. The patients with jaundice should be treated with laxatives and should be fed on a meat-free diet containing milk and fresh vegetables.

The prognosis of cases with an extreme anemia is grave. A considerable number of cases with jaundice recover, although the recovery proceeds very slowly and requires six months or more. See Crawford (41) and Bower (42).

Summary

The principal results obtained in the field investigation are the following:

The examination of 237 T.N.T. workers in a shell-filling plant showed that 72 per cent. of these workers were anemic. This anemia exhibits the same features as the anemia observed in dogs poisoned with T.N.T., *viz.*, a reduction in the hemoglobin percentage, the presence of anisocytosis and poikilocytosis, polychromatophilia, fragmentation of red cells, and the appearance of nucleated and reticulated red cells in the circulating blood. The anemia may or may not be associated with a leukocytosis, leukopenia, or relative lymphocytosis.

Cyanosis, pallor, and dermatitis were frequently seen in these workers, and indicate that the poison is absorbed. The absence of these symptoms, however, is not proof of the absence of poisoning. A marked anemia may exist without clinical symptoms.

Examination of the urine nearly always reveals the presence of a derivative of T.N.T. (hydroxylamine compound). The presence or absence of this substance in the urine, as determined by the Webster test, is of no prognostic value. The examination of the blood, with particular reference to its hemoglobin content, the character of the red cells and the appearance of a slight icteric discoloration of the skin or conjunctivae, is recommended as a reliable guide for the diagnosis of T.N.T. poisoning.

No cases of toxic jaundice or aplastic anemia were found among these workers. It is suggested that the so-called aplastic anemia observed in T.N.T. workers represents the final stage of the anemia so commonly found in persons exposed to T.N.T., and that in the earlier stages of poisoning the blood destruction is essentially due to the injury of the red cells which secondarily leads to phagocytosis of the injured cells by the spleen, liver, and bone marrow. In toxic jaundice the hemoglobin and red cell count may be normal or reduced. In the first case blood regeneration probably compensates for blood destruction. The liver lesions found at necropsy may be due to a pre-existing functional or histological abnormality of the liver cells which has been aggravated by the T.N.T. intoxication.

The poison may be absorbed through the skin, the lungs, or the gastro-intestinal tract. Means of prevention should be strictly observed. Skin contact and air contamination should be reduced to a minimum. The principal measures for skin protection should consist in wearing clean overalls and head dress, and in using sulphite solution for the removal of T.N.T. from the exposed skin surface before the worker leaves the factory. Personal cleanliness in working and in the care of the body should be emphasized. Gloves and

respirators are of no value. There should be efficient ventilation of the workrooms; the floors, booster cavities, etc., should be cleaned by means of an induced draft. The workers should be instructed to eat a nutritious diet containing a fair amount of meat. They should be examined at least every week or two for the presence of clinical symptoms and anemia. Intermittent employment on T.N.T. work reduces the health hazard somewhat, but does not necessarily insure against poisoning because the system retains T.N.T. for a considerable length of time. Preliminary medical examination should insure, as nearly as possible, that no person is employed who shows the slightest evidence of liver disease or anemia.

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BOOK REVIEWS

The Health of the Industrial Worker. By Edgar L. Collis, B.Ch., M.A., M.D. (Oxon.), M.R.C.P. (Lond.), M.R.C.S. (Eng.), Mansel Talbot Professor of Preventive Medicine, Welsh National School of Medicine; Member of Industrial Fatigue Research Board; late H.M. Medical Inspector of Factories; Member of Health of Munition Workers Committee; Milroy Lecturer, R.C.P. (1915); Director of Welfare and Health, Ministry of Munitions; and Major Greenwood, M.R.C.P. (Lond.), M.R.C.S. (Eng.), Member of Industrial Fatigue Research Board; Reader in Medical Statistics, University of London; late Statistician to Lister Institute; Head of Medical Research Branch, Ministry of Munitions; Arris and Gale Lecturer, R.C.S. (1908). Containing a chapter on RECLAMATION OF THE DISABLED by Arthur J. Collis, M.A., M.D. (Cantab.), M.R.C.S. (Eng.), D.P.H. (Durh.), Medical Superintendent, Ministry of Pensions Hospital, Leicester; late Temp. Lieut.-Col. R.A.M.C. With an introduction by Sir George Newman, K.C.B., D.C.L., M.D., F.R.C.P. Illustrated. Cloth. Pp. 450 with illustrations and index. Philadelphia: P. Blakiston's Son & Co., 1921.

Sir George Newman in his introduction to this book gives the point of view which it so forcibly presents: "While at first sight accidents, poisoning, and a high occupational death rate are impressive, it cannot, I think, be doubted that the less dramatic side of the problem is, in fact, the more important — namely, the lost time and incapacity due to ill-health. For this is so widely prevalent as to be almost universal, in all districts, at all ages, in all trades, there is this vast mass of wasted life and energy due for the most part to preventable maladies — in their turn largely attributable to remediable conditions of industry, or to neglect of hygiene."

After reading this introduction one is not surprised to find an absence of chapters upon industrial toxicology and upon the minutiae of industrial medicine and surgery. We are offered instead a view of a new field in preventive medicine, a field which covers the working life of a large portion of our population. Such a book places industrial hygiene in its proper place, displays its possibilities of growth, and removes it from the position of a rather feeble adjunct to pharmacology and to the established practice of medicine and surgery.

The chapter headings will give the best idea of the scope of the work: I. Industry and Health — A Retrospect; II. Review of Industrial Legislation; III. The Utilization of Statistical Methods in Industrial Preventive Medicine; IV. The Effects of Industrial Employment upon Health as Indicated by Vital Statistics; V. Industrial Activity and Fatigue; VI. Tuberculosis and Industry; VII. Cancer and Industry; VIII. Causation and Prevention of Accidents; IX. Industrial Employment of Women; X. The Feeding of the Industrial Worker; XI. Food at the Factory; XII. The Use of Alcoholic Beverages by the Industrial Worker; XIII. Reasons for and Methods of Ventilation; XIV. Lighting; XV. Washing Accommodation — Sanitary Accommodation — Drinking Water — Working Clothes — Cloak Rooms — Seats; XVI. Labour Turnover or Industrial Wastage; XVII. Supervision of Industrial Health; XVIII. Reclamation of the Disabled.

The treatment of these subjects is of high order and the difficulty of handling them is great because in the main they are at the beginning of their development. Of particular merit are the chapters upon fatigue, ventilation and tuberculosis. The addition to each chapter of well-selected groups of references is an addition of value and especially useful in a developing subject.

While to the American reader it may seem that the treatment should have extended outside British experiences to a greater degree than occurs, this does not seem of importance to the reviewer. The book is an exposition of principles, of a modern point of view upon which schools may be founded. In such an effort the experiences recounted are necessarily international in their applicability and significance.

It is a pleasure to recommend the work to forward-looking readers, and it is hoped that those who have seen the subject of industrial hygiene as the weak handmaid of medicine and surgery will find a stimulating refutation of their views in this volume. — *Cecil K. Drinker.*

BOOKS RECEIVED

Books received are acknowledged in this column, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

Principles of Hygiene. A Practical Manual for Students, Physicians, and Health-Officers. By D. H. Bergey, A.M., M.D., Dr. P.H., Assistant Professor of Hygiene and Bacteriology, University of Pennsylvania. Illustrated. Cloth. Seventh Edition, thoroughly revised. Pp. 556 with illustrations, preface, index, and appendix. Philadelphia and London: W. B. Saunders Company, 1921.

Textbook of Surgical Nursing. By Ralph Colp, A.B., M.D., Instructor in Surgery, Columbia University, New York; Lecturer in Surgical Nursing, Presbyterian Hospital Training School for Nurses, New York; Adjunct Visiting Surgeon, Volunteer Hospital, New York; Chief of Surgical Clinic, Beth Israel Hospital, New York; Formerly Lecturer in Nursing and Health, Teachers College, Columbia University, New York; and Manelva Wylie Keller, B.S., R.N., Formerly Chief Operating Room Nurse, St. Luke's Hospital, New York, and Anesthetist, St. Luke's Hospital, New York, and Mobile Hospital No. 2, A. E. F., France. Cloth. Pp. 453 with appendix, illustrations, and index. New York: Macmillan Company, 1921.